



FIG. 15.—Annual rainfall of Porto Rico in a wet year, 1901. (Rainfall in inches; small italic figures give altitudes in feet.)

THE MECHANISM OF CYCLONES.

By F. J. W. WHIPPLE.

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The distribution of pressure and temperature in cyclones in the Temperate Zone has been learned from the analysis of the records from the meteorographs carried by [sounding] balloons. Up to a height of 8 or 9 kilometers the cyclone is composed of air cooler than its surroundings: at greater heights, i. e., in the stratosphere, the cyclone contains comparatively warm air. The lower limit of the stratosphere is depressed in the cyclone. This temperature distribution indicates that the air constituting the lower part of the cyclone has recently ascended, whereas the upper air has recently fallen, and accordingly the arrival of a cyclone is marked by an outflow of air at the bottom of the stratosphere and an inflow below. At the beginning of the present paper the amount of this displacement of air is estimated on the assumption that there is no direct exchange of heat, and it is shown that the outflow is concentrated between the 7th and 10th kilometers and is about 6.5 times the net loss of air as estimated by the fall of pressure at the earth's surface.

It is pointed out that a cyclone may be regarded as a disturbance in the stream of air which flows from west to east in the Temperate Zone, and the form of the isobars obtained by superimposing the permanent pressure distribution and the temporary cyclonic distribution is discussed. It is shown that when due allowance is made for the curvature and the progressive motion of these isobars, the gradient wind at certain heights is much less than it would have been if the curvature were inappreciable, so that at these heights the air supply from the rear to the front of the cyclone fails and the cyclone appears to move under the influence of suction applied at the base of the stratosphere. The explanation may be summarized as follows:

If the flow of air at any level were entirely horizontal and along the isobars, and if the changes of density were

negligible, then the condition for continuity would require the velocity to be inversely proportional to the distance between the isobars, i. e., the velocity would be directly proportional to the pressure gradient. This condition is not satisfied, however, in regions where the air trajectories are curved. The pressure has to produce the centripetal acceleration in the curved path in addition to overcoming the tendency to turn to the right, which is the feature of all horizontal motion in our hemisphere. Accordingly the actual velocity where the isobars are curved is less than it should be to secure continuity and maintain a stationary distribution of pressure. The effect of curvature in reducing the velocity is greatest at the heights where the winds are strongest, and therefore the suction effect is concentrated near the base of the stratosphere.

The general argument is supported by the analysis of two special cases.

CAUSES CONTRIBUTORY TO THE ANNUAL VARIATION OF LATITUDE.¹

By HAROLD JEFFREYS.

[Abstract.]

The motion of the terrestrial pole relative to the surface of the earth was shown by Chandler to consist mainly of two parts, viz, a circular motion with a period of 430 days, and an annual motion in an ellipse. The former is considered to be identical with the free vibration called the polhode motion, or Eulerian nutation. The latter is generally attributed to meteorological causes. An elaborate analysis of these causes is published by Mr. H. Jeffreys in the "Monthly Notices." The author examines separately the effects of atmospheric motion, oceanic movements, precipitation, vegetation, and polar ice. He concludes that "the known meteorological causes are apparently capable of giving a fairly good account of the observed annual motion of the pole, the errors found being perhaps within the range of uncertainty of the data."

¹ See Monthly notices, Roy. astron. soc., London, April, 1916, 76: 499-525. Pl. 3.